

Waste Energy Management and Recovery: A Novel Solution to Energy Conservation and Sustainable Development

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Abstract

In this paper, we present two major energy recovery systems viz. Exhaust Air Recovery and Waste Heat Recovery. By practically deploying these systems, we show how these systems help in conversion of waste energy into useful energy. These systems, even if implemented at small scale will not only save a lot of energy but also reduce carbon dioxide emission and hence preserve the environment.

Keywords: Exhaust air recovery, waste heat recovery, energy conservation

1. Introduction

Energy is one of the major inputs for economic development of any country. Of all, the energy sector assumes a critical importance in view of the ever increasing energy needs requiring huge investments to meet them. Some of the strategies that can be used to meet future challenges to energy security include: building stockpiles, diversification of energy supply sources, increased capacity of fuel switching, development of renewable energy resources and sustainable development.

However, of all these options, the simplest and the most attainable is reducing demand through persistent energy conservation efforts and recycling the waste energy, that is, converting one form of energy into other useful form. In this paper, we discuss two energy conversion processes which are very easy to implement in any house, industry, hospital or restaurant.

- Use of exhaust air to generate electricity (**exhaust air recovery**)
- Use of low grade heat for warming water/ producing steam (**waste heat recovery**)

2. Exhaust Air Recovery

We know that wind is not a common phenomenon everywhere. For a successful running of a windmill, a steady wind speed of about 20 km per hour is needed. But we can use exhaust air from one or more ventilation systems of a bounded area such as a mine, a tunnel or some other area requiring ventilation. Their system utilizes existing wind-powered electric generating equipment in front of the exhaust fan of the ventilation systems. Even air from low volume air conditioning exhausts can be utilized for generating electricity.

We use an existing wind powered generator and a means of mounting the generator in proximity to the exhaust outlet. The shroud directs the air conditioner fan exhaust flow to a wind turbine, having two or more blades positioned in the air flow, so when the air flow passes over the blades, the shaft of the turbine is spun and electricity is generated thereby. The shroud also serves to protect anyone around or near the turbine from injury by the blades spinning in the exhaust fan airflow.

2.1 Deployment and Results

For deployment of the design, we install a fan made of cast steel in front of exhaust plant as shown in Figure 1. The fan is connected to a dynamo of 230V, 6kVA rating through a small pulley on the same shaft. The output of dynamo is connected to load as required. Area of the window used for expelling exhaust air is $1.61 \times 1.99 \text{ m}^2$. By controlling the rate of flow of exhaust air, we record the data shown in Table I.

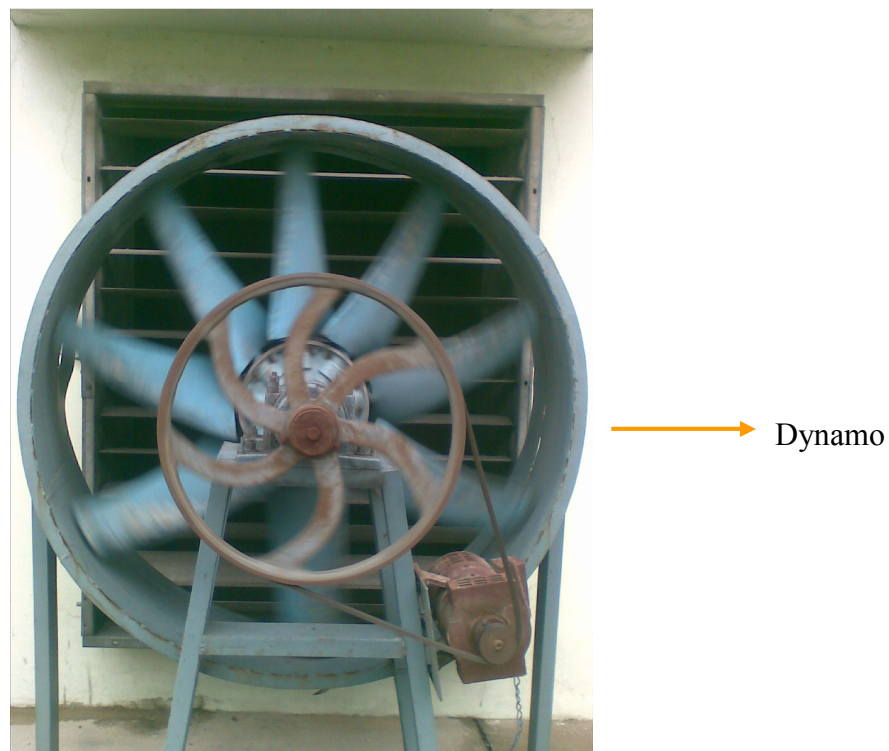


Figure 1. Fan installed in front of the exhaust window. A dynamo can also be seen.

TABLE I
VOLTAGE PRODUCED DURING THE DEPLOYMENT OF EXHAUST AIR RECOVERY SYSTEM

Sr. No.	Velocity of exhaust air (m/s)	Fan rpm	Actual rpm of small pulley	Volts produced	Load that can be connected
1.	6.64	175	1220	190	CFL 2 Nos. (20 W each)
2.	6.97	200	1390	230	100W + CFL 2 Nos. (20 W Each)

2.2 Benefits

The benefit of this exhaust air recovery in the form of electricity lies in industries and hotels where exhaust air from fans and chiller plants can be used to generate electricity. It will reduce the load on power plants and hence help in the reduction of carbon dioxide emission thus improving the environment. It will also reduce the wastage of energy in the form of transmission losses which account for nearly 27 percent of the total electricity generated. As an example, say a thermal power plant generates 10 MW of electricity in a day. 10% of the electricity is lost in the power station itself leaving only 9 MW for transmission. Owing to transmission losses (about 10%), only 8.1 MW reaches the substations/feeders. The distribution losses reduce it further to about 7.3 MW. Here, we see that a net of 27% electricity generated goes as waste. But in case of electricity generated by the exhaust air recovery, the losses will be considerably reduced because the point of generation is nearly the same as point of consumption (Figure 2).

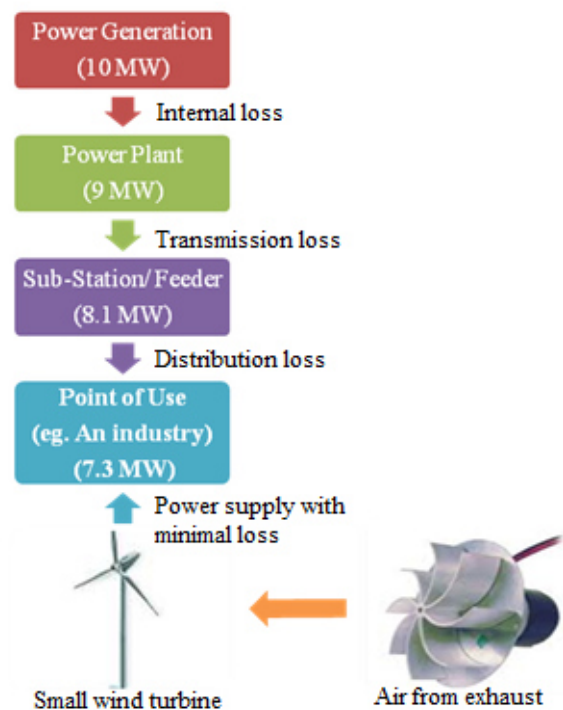


Figure 2. A schematic showing benefits of using power from exhaust air recovery

3. Waste Heat Recovery

Waste heat is heat, which is generated in a process by way of fuel combustion or chemical reaction, and then dumped into the environment even though it could still be reused for some useful and economic purpose. The essential quality of heat is not the amount but rather its value. The strategy to recover this heat depends in part on the temperature of the waste heat gases and the economics involved.

Large quantity of hot flue gases is generated from boilers, kilns, ovens, furnaces and air conditioning systems. If some of this waste heat could be recovered, a consumable amount of primary fuel could be saved. The energy lost in the waste gases cannot be fully recovered. However, much of the heat could be recovered and loss minimized. There can be three types of heat recovery: High temperature heat recovery, Medium temperature heat recovery and Low temperature heat recovery

In this paper, we discuss the recovery of heat from air conditioning systems and chiller plants which come under the category of medium and low temperature heat recovery depending upon the size of the plant in consideration.

3.1 Waste Heat Boilers

Waste heat boiler is an ordinary water tube boiler in which the hot exhaust gases from air conditioning/ chiller plants pass over a number of parallel tubes containing water. The water is warmed/ vaporized in tubes depending upon the temperature and heat capacity of the exhaust gases.

Because the exhaust gases are usually in the medium/ low temperature range and in order to conserve space, a more compact boiler can be produced if the water tubes are finned in order to increase the effective heat transfer area on the gas side.

The possible design for the boiler is shown in Figure 3.

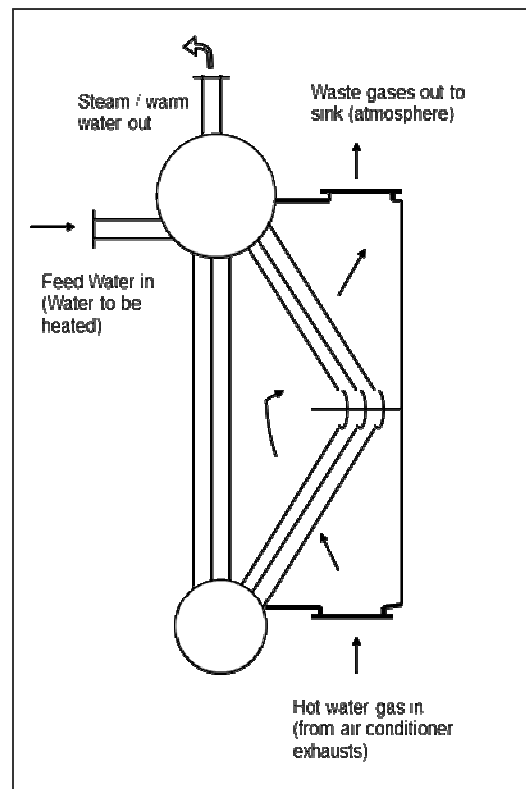


Figure 3. Proposed design for the waste heat boiler

3.2 Results

In general, 1 ton of refrigeration is removing 3.88 kJ of heat in 1 second that is equivalent to 3.88 kW of power. Thus if 1 ton air conditioner runs for an hour, it consumes 3.88 kWh of energy and it is equivalent to 1.4×10^7 Joules of energy. Practically, considering efficiency to be only 20-25%, this is a huge amount of energy which can be used for boiling water and other heating purposes. If not harnessed, this heat energy goes waste as loss to the ambient i.e. air.

3.3 Benefits

The major benefit with these types of boilers could be in houses, hospitals, hotels and industries where big air conditioning systems are installed and they reject a large amount of waste heat to the sink (atmosphere) continuously. These are the places where warm water/steam is also required round the clock for many of the operations. This system, if installed with each air conditioning system could help save a lot of energy in terms of power used and indirectly reduce the pressure on power plants. This will improve the quality of environment as the amount of carbon dioxide released into the atmosphere will decrease greatly. Apart from these benefits, some of the indirect benefits of waste heat recovery include:

Reduction in pollution: A number of toxic combustible wastes such as carbon monoxide gas, sour gas, carbon black off gases, oil sludge, acrylonitrile and other plastic chemicals etc releasing to atmosphere if when burnt in the incinerators serves dual purpose i.e. recovers heat and reduces the environmental pollution levels.

Reduction in equipment sizes: Waste heat recovery reduces the fuel consumption, which leads to reduction in the flue gases produced. This results in reduction in equipment sizes of all flue gas handling equipments such as fans, stacks, ducts etc.

Reduction in auxiliary energy consumption: Reduction in equipment sizes gives additional benefits in the form of reduction in auxiliary energy consumption like electricity for fans, pumps etc.

4. Conclusion

In this paper, we have presented the techniques employed to recover waste energy and convert it into useful form. It is not that these technologies are not in use at present. We all are aware of the wind mills and heat pumps or compressors. But the main emphasis should be on using these technologies in a more beneficial way so that we get commercial benefits as well as preserve our environment. One of the key problems being faced in installing

these systems is of high initial cost and unavailability of equipments. The problems can be addressed by popularizing these concepts. This will surely help in initial cost reduction.

Another important issue which needs to be addressed is of environment. The global warming is increasing day by day due to increase in emission of carbon dioxide into the atmosphere. By following energy recycling and recovery, we can greatly reduce the carbon dioxide emission and add to the quality of environment. In this paper, we have emphasized that be it on small scale, waste energy recycling is a must if we have sustainable development in the future.

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